Growth and Parental Preference for Education in China

Angus C. Chu   Yuichi Furukawa   Dongming Zhu

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Abstract

This study explores the implications of education preference in an innovation-driven growth model that features an interaction between endogenous technological progress and human capital accumulation. Parents invest in children's education partly due to the preference for their children to be educated. We consider a preference parameter that measures the degree of this cultural preference for education. We find that a society such as China in which parents place a high value on education accumulates more human capital, which is conducive to innovation, but the larger education investment also crowds out resources for R&D. As a result, a stronger cultural preference for education has an inverted-U effect on long-run growth. We also derive a closed-form solution for the transitional path of the equilibrium growth rate from any initial state and find that a strengthening of education preference causes an initial negative effect on growth. Finally, we consider a number of extensions to the benchmark model.

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Keywords: education, endogenous growth, human capital, innovation

Angus C. Chu: anguscccc@gmail.com. Department of Economics, Finance and Accounting, Management School, University of Liverpool, Liverpool, United Kingdom. Yuichi Furukawa: you.furukawa@gmail.com. School of Economics, Chukyo University, Nagoya, Japan. Dongming Zhu: zhu.dongming@mail.shufe.edu.cn. School of Economics & Key Laboratory of Mathematical Economics, Shanghai University of Finance and Economics, Shanghai, China. The authors are grateful to Ping Wang, an anonymous Associate Editor and an anonymous Referee for their helpful suggestions and insightful comments.

1 Introduction

It is well known that the Chinese society places a very high value on education. In China's Song Dynasty, Emperor Zhenzong (968-1022) wrote his famous *Urge to Study Poem* in which an often quoted verse is "in books one finds golden mansions and maidens as beautiful as jade." Also in the Song Dynasty, a poet, Wang Zhu, wrote in his famous *Child Prodigy Poem*, "all pursuits are of low value; only studying the books is high." This emphasis on education can be traced back to Confucianism, which emphasizes the importance of education. Studying the origins of this strong cultural preference for education in China, Kipnis (2011) notes that education "invokes a system of prestige in which those with educational accomplishments are marked as superior to the non-educated." Even in the case of Chinese families in the US, this cultural preference for education still exerts influences on parents' involvement in children's education. For example, from their survey data, Chen and Uttal (1988) find that Chinese parents have higher expectations on their children's academic achievement and spend more time working with children on their homework than American parents. Furthermore, Chen and Uttal (1988) argue that these different behaviors can be explained by differences in cultural values.[1] However, is a strong parental preference for education necessarily good for the economy? A BBC News article[2] discusses the costs of this "education fever" in China as well as South Korea, which also shares the Confucian values, and reports that in South Korea, "the government believes 'education obsession' is damaging society".

In this study, we use a growth-theoretic framework to explore the macroeconomic implications of parental preference for education. The growth-theoretic framework is an innovation-driven growth model that features an interaction between endogenous technological progress and human capital accumulation. Parents invest in their children's human capital due to the subjective utility that they derive from their children's education. We consider a preference parameter that measures the degree of this parental preference for education. We find that a society such as China in which parents place a high value on education accumulates more human capital, which is conducive to innovation, but the larger education investment also crowds out resources for R&D investment. As a result, a stronger parental preference for education has an inverted-U effect on the steady-state equilibrium growth rate due to the presence of both positive and negative effects.

We also analytically derive the complete transitional path of the equilibrium growth rate from any initial state when the degree of parental preference for education increases. We find that an increase in the degree of education preference has an initial negative effect on the equilibrium growth rate due to the crowding-out effect of education investment on R&D investment. However, as the level of human capital increases, the equilibrium growth rate also increases due to the positive effect of human capital on innovation. When we compare between two steady states, we find that the new steady-state equilibrium growth rate may be higher or lower than the initial steady-state equilibrium growth rate, depending on the relative magnitude of the negative crowding-out effect of education investment and the positive effect of human capital on innovation and growth.

Furthermore, we consider a number of extensions to the benchmark model by allowing for a

[1] See also Huang and Gove (2012) for a discussion of Confucianism's influence on the Chinese culture and educational practice of Chinese families in the United States.

[2] "Asia's Parents Suffering 'Education Fever'". BBC News, 22 October 2013.

pecuniary transfer from parents to children and public investment in education. We find that our result of an inverted-U effect of education preference on growth is robust to these extensions. Therefore, in all versions of the model, a strong parental preference for education indeed has a certain "damaging" effect on the society by exerting a negative effect (in addition to the usual positive effect) on the growth rate of the economy. The underlying assumption behind this negative effect is that parents investing more of their time in their children's education carries an opportunity cost that crowds out other productive activities. For example, a recent SCMP News article[3] describes a growing trend of educated parents in China quitting their careers to educate their children.

This study contributes to the literature on R&D-driven innovation and economic growth.[4] Early studies in this literature do not consider human capital accumulation. More recent studies, such as Eicher (1996), Zeng (1997, 2003), Strulik (2005, 2007), Strulik *et al.* (2013), Chu *et al.* (2013), Hashimoto and Tabata (2016) and Prettner and Strulik (2016), explore human capital accumulation and its interaction with endogenous technological progress in the R&D-based growth model. However, these studies either do not explore the effects of parental preference for education or they find an unambiguously positive effect of education preference on growth. Taking into account the negative crowding-out effect of education, we find that a stronger parental preference for education has a negative effect on the transitional growth rate and an inverted-U effect on the long-run growth rate.

The rest of this study is organized as follows. Section 2 presents the benchmark model. Section 3 explores the implications of parental preference for education. Section 4 considers a number of extensions. The final section concludes.

2 The benchmark model

We consider a discrete-time version of the seminal R&D-based growth model in Romer (1990). We extend the Romer model by considering a simple structure of overlapping generations and human capital accumulation. Each individual is endowed with one unit of time to be allocated between leisure, work and the education of her child.[5] We follow previous studies[6] to assume that individuals derive utility from their children's education. Furthermore, they supply labor that is embodied with human capital to earn a wage income. For simplicity, we follow previous studies to assume that individuals only consume goods when they are old. In this case, they

[3] "Home Freer: Chinese Mothers Quit Jobs to Care for the Kids". South China Morning Post, 9 November 2015.

[4] See Romer (1990), Segerstrom *et al.* (1990), Grossman and Helpman (1991) and Aghion and Howitt (1992) for seminal studies in this literature.

[5] In this study, we do not consider endogenous fertility; see for example Chu *et al.* (2013), Strulik *et al.* (2013), Prettner and Strulik (2016) and Hashimoto and Tabata (2016) for an analysis of human capital accumulation and endogenous fertility in the R&D-based growth model. In the case of China, the number of children was not freely chosen by most parents due to the one-child policy, which has been recently changed to a two-child policy.

[6] See for example Glomm and Ravikumar (1992) and Futagami and Yanagihara (2008). In this literature on parental investment in human capital and economic growth, studies focus on human capital accumulation as the sole engine of economic growth. The present study complements these studies by exploring parental investment in human capital as well as its interaction with endogenous technological progress.

save all of their wage income when they are young and consume their asset income when they are old.

2.1 Individuals

In each generation, there is a unit continuum of individuals. An individual who works at time t has the following utility function indexed by a superscript t:

$$U^t = u(l_t, C_{t+1}, H_{t+1}) = \eta \ln l_t + \ln C_{t+1} + \gamma \ln H_{t+1}. \tag{1}$$

l_t denotes the individual's leisure at time t, and the parameter $\eta \geq 0$ captures leisure preference.[7] C_{t+1} denotes the individual's consumption at time $t+1$. H_{t+1} denotes the level of human capital possessed by the individual's child. The parameter $\gamma > 0$ measures the degree of parental preference for education (i.e., γ is the utility weight that an individual places on her child's human capital). The amount of time e_t a parent invests in her child's education determines her level of human capital according to the following equation:

$$H_{t+1} = \phi e_t + (1-\delta)H_t, \tag{2}$$

where $\phi > 0$ is an education efficiency parameter and $\delta \in (0,1)$ is the depreciation rate of human capital that the parent passes onto her child.[8] Following previous studies, we assume for simplicity that education is the only form of bequest.

Individuals use their remaining time endowment $1 - l_t - e_t$ combined with their human capital H_t to earn a wage income $w_t(1-l_t-e_t)H_t$. Given that individuals consume only when they are old, their consumption at time $t+1$ is given by

$$C_{t+1} = (1 + r_{t+1})w_t(1 - l_t - e_t)H_t, \tag{3}$$

where r_{t+1} is the real interest rate. Substituting (2) and (3) into (1), we can express an individual's optimization problem as follows.

$$\max_{e_t,\, l_t} U^t = \eta \ln l_t + \ln[(1 + r_{t+1})w_t(1 - l_t - e_t)H_t] + \gamma \ln[\phi e_t + (1-\delta)H_t],$$

taking $\{r_{t+1}, w_t, H_t\}$ as given. The utility-maximizing levels of l_t and e_t are respectively

$$l_t = \eta \frac{\phi + (1-\delta)H_t}{\phi(1+\eta+\gamma)}, \tag{4}$$

$$e_t = \frac{\phi\gamma - (1+\eta)(1-\delta)H_t}{\phi\,(1+\eta+\gamma)}. \tag{5}$$

Substituting (5) into (2) yields the level of human capital at time $t+1$ as

$$H_{t+1} = \frac{\gamma}{1+\eta+\gamma}\left[\phi + (1-\delta)H_t\right], \tag{6}$$

[7] We consider endogenous leisure to allow individuals to choose between reducing their time spent on leisure and work when they want to increase their time spent on their children's education. Our results are robust to the absence of endogenous leisure (i.e., $\eta = 0$).

[8] Our results are robust to $\delta \to 1$ (i.e., parents' human capital does not transfer to their children).

which is the accumulation equation of human capital and shows that the dynamics of H_t is stable. Therefore, given any initial H_0, H_t always converges to its steady state.

In the steady state, the level of leisure is $l^* = \eta/(1+\eta+\delta\gamma)$, which is decreasing in γ, whereas the level of education is $e^* = \delta\gamma/(1+\eta+\delta\gamma)$, which is increasing in γ. The steady-state level of human capital is $H^* = \phi\gamma/(1+\eta+\delta\gamma)$, which is also increasing in γ. However, the steady-state level of human-capital-embodied labor supply is

$$(1-l^*-e^*)H^* = \frac{\phi\gamma}{(1+\eta+\delta\gamma)^2}, \tag{7}$$

which is an inverted-U function of γ. The negative effect of γ on human-capital-embodied labor supply is due to the crowding-out effect of education, which is captured by $1-l^*-e^* = 1/(1+\eta+\delta\gamma)$. Intuitively, an increase in γ causes parents to devote more time to their children's education e^*. As a result, they have to devote less of their time to other productive activities. Although they also reduce leisure l^*, the reduction in l^* only partly offsets the increase in e^*, resulting into an overall decrease in $1-l^*-e^*$.

2.2 Final goods

Final goods Y_t are produced by competitive firms using the following production function:

$$Y_t = H_{Y,t}^{1-\alpha} \sum_{i=1}^{N_t} X_t^{\alpha}(i), \tag{8}$$

where $H_{Y,t}$ is human-capital-embodied labor devoted to production and $X_t(i)$ is intermediate good $i \in [1, N_t]$. The firms take as given the output price (normalized to unity) and input prices w_t and $p_t(i)$. The familiar conditional demand functions for $H_{Y,t}$ and $X_t(i)$ are respectively

$$w_t = (1-\alpha)Y_t/H_{Y,t}, \tag{9}$$

$$p_t(i) = \alpha \left[H_{Y,t}/X_t(i)\right]^{1-\alpha}. \tag{10}$$

2.3 Intermediate goods

There is a number of differentiated intermediate goods $i \in [1, N_t]$. We consider the following simple production process that is commonly used in the literature. Specifically, we assume that one unit of intermediate goods is produced by one unit of final goods. In this case, the profit function is given by

$$\pi_t(i) = p_t(i)X_t(i) - X_t(i). \tag{11}$$

The familiar unconstrained profit-maximizing price is $p_t(i) = 1/\alpha$. Here we follow Goh and Olivier (2002) and Iwaisako and Futagami (2013) to introduce patent breadth $\mu > 1$ as a policy variable,[9] such that

$$p_t(i) = \min\{\mu, 1/\alpha\}. \tag{12}$$

[9] The presence of monopolistic profits attracts potential imitation; therefore, stronger patent protection allows monopolistic producers to charge a higher markup without losing their markets to potential imitators. This formulation of patent breadth captures Gilbert and Shapiro's (1990) seminal insight on "breadth as the ability of the patentee to raise price".

We focus on the more realistic case in which $\mu < 1/\alpha$.[10] Substituting $p_t(i) = \mu$ into (10) shows that $X_t(i) = X_t$ for all $i \in [1, N_t]$. In this case, (11) becomes

$$\pi_t = (\mu - 1)X_t = (\mu - 1)\left(\frac{\alpha}{\mu}\right)^{1/(1-\alpha)} H_{Y,t}, \tag{13}$$

where the second equality follows from (10).

2.4 R&D

Denote v_t as the value of an intermediate good invented at time t. The value of v_t is equal to the present value of future profits given by[11]

$$v_t = \sum_{s=t+1}^{\infty}\left[\pi_s / \prod_{\tau=t+1}^{s}(1 + r_\tau)\right]. \tag{14}$$

Competitive entrepreneurs employ human-capital-embodied labor $H_{R,t}$ for R&D. The innovation process is

$$\Delta N_t = \theta N_t H_{R,t}, \tag{15}$$

where $\Delta N_t \equiv N_{t+1} - N_t$. The parameter $\theta > 0$ denotes an R&D productivity parameter, and N_t captures intertemporal knowledge spillovers as in Romer (1990). The zero-profit condition is given by

$$\Delta N_t v_t = w_t H_{R,t} \Leftrightarrow \theta N_t v_t = w_t. \tag{16}$$

2.5 Aggregation

Substituting $X_t = (\alpha/\mu)^{1/(1-\alpha)} H_{Y,t}$ into $Y_t = H_{Y,t}^{1-\alpha} N_t X_t^{\alpha}$ yields the aggregate production function given by

$$Y_t = \left(\frac{\alpha}{\mu}\right)^{\alpha/(1-\alpha)} N_t H_{Y,t} \tag{17}$$

and the amount of intermediate goods given by $N_t X_t = \alpha Y_t/\mu$. The resource constraint on final goods is

$$C_t = Y_t - N_t X_t = \left(1 - \frac{\alpha}{\mu}\right) Y_t. \tag{18}$$

The resource constraint on human-capital-embodied labor input is

$$(1 - l_t - e_t)H_t = H_{Y,t} + H_{R,t}. \tag{19}$$

[10] Given a labor share $1 - \alpha$ of roughly two-thirds, the unconstrained markup ratio is $1/\alpha = 3$, which is unrealistically large. However, all our results are robust to the case of $p_t(i) = 1/\alpha$.

[11] A new variety invented at time t will only start generating profits in the next period.

2.6 Equilibrium

The equilibrium is a sequence of allocations $\{X_t(i), Y_t, C_t, H_{Y,t}, H_{R,t}, H_t, e_t, l_t\}$ and prices $\{p_t(i), w_t, r_t, v_t\}$ such that the following conditions are satisfied:

- individuals choose $\{e_t, l_t\}$ to maximize utility taking $\{r_{t+1}, w_t, H_t\}$ as given;
- competitive final goods firms choose $\{X_t(i), H_{Y,t}\}$ to maximize profit taking $\{p_t(i), w_t\}$ as given;
- monopolistic intermediate goods firms choose $\{p_t(i), X_t(i)\}$ to maximize profit (11) taking (10) as given;
- competitive entrepreneurs in the R&D sector employ $\{H_{R,t}\}$ to maximize profit taking $\{w_t, v_t\}$ as given;
- the resource constraint on final goods holds such that $Y_t = N_t X_t + C_t$;
- the resource constraint on human-capital-embodied labor holds such that $H_{Y,t} + H_{R,t} = (1 - l_t - e_t)H_t$;
- the amount of saving equals the value of assets such that $w_t(1 - l_t - e_t)H_t = N_{t+1}v_t$.

3 Parental preference for education

In this section, we explore the implications of parental preference for education on economic growth. Section 3.1 focuses on the balanced growth path. Section 3.2 considers the transitional paths of human capital and the equilibrium growth rate.

3.1 Balanced growth path

Human-capital-embodied labor allocations $\{H_{Y,t}, H_{R,t}\}$ are stationary in the steady state. Then, (13) implies that π_t is also stationary in the steady state. As a result, the steady-state version of (14) simplifies to $v = \pi/r$. Substituting this condition into the R&D zero-profit condition in (16), we have $\theta N_t \pi/r = w_t$, where $N_t\pi = \alpha Y_t(\mu - 1)/\mu$ and w_t is given by (9). Solving these conditions yields

$$H_Y = \frac{\mu}{\mu - 1}\left(\frac{1-\alpha}{\alpha}\right)\frac{r}{\theta}. \tag{20}$$

The next step is to determine the steady-state equilibrium interest rate r. Wage income at time t is $w_t(1 - l_t - e_t)H_t = w_t(H_{Y,t} + H_{R,t})$, which is also the total amount of saving in the economy at time t. The total value of assets in the economy at the end of time t is $N_{t+1}v_t$, which includes the new varieties created at time t. Given the overlapping-generation structure of the economy, the amount of saving must equal the value of assets such that

$$w_t(1 - l_t - e_t)H_t = N_{t+1}v_t \Leftrightarrow w_t(H_Y + H_R) = (1 + \theta H_R)N_t\pi/r, \tag{21}$$

where $N_t\pi = \alpha Y_t(\mu-1)/\mu$ and w_t is given by (9). Solving these conditions, we obtain

$$\frac{(1-\alpha)(H_Y+H_R)}{H_Y} = \frac{\alpha(1+\theta H_R)}{r}\left(\frac{\mu-1}{\mu}\right), \tag{22}$$

which determines the equilibrium interest rate that equates the amount of saving to the value of assets in the economy.

Solving (7), (19), (20) and (22) yields the steady-state equilibrium values of $\{r^*, H_Y^*, H_R^*\}$.

$$r^* = \frac{\alpha}{1-\alpha}\left(\frac{\mu-1}{\mu}\right), \tag{23}$$

$$H_Y^* = \frac{1}{\theta}, \tag{24}$$

$$H_R^* = \frac{\phi\gamma}{(1+\eta+\delta\gamma)^2} - \frac{1}{\theta}, \tag{25}$$

which shows that H_R^* is an inverted-U function of γ. From (15) and (25), the steady-state equilibrium growth rate of technology (and also output) is given by

$$g^* \equiv \frac{\Delta N_t}{N_t} = \theta H_R^* = \frac{\theta\phi\gamma}{(1+\eta+\delta\gamma)^2} - 1 \geq 0, \tag{26}$$

which is also an inverted-U function of γ. Specifically, the growth-maximizing value of γ is given by $(1+\eta)/\delta > 0$. Intuitively, a higher depreciation rate δ of human capital leads to a higher steady-state level of education e^* that mitigates the negative effect on human capital H^*, and hence, a weaker education preference γ is needed to reach the level of education that maximizes the level of human-capital-embodied labor $(1-l^*-e^*)H^*$. In contrast, a stronger preference η for leisure reduces e^* and requires a stronger education preference γ to reach the level of education that maximizes $(1-l^*-e^*)H^*$. To ensure that there exists an intermediate range of γ in which the steady-state equilibrium growth rate g^* is positive, we impose the following parameter restriction: $\theta\phi > 4(1+\eta)\delta$. Under this parameter restriction, there still exists a lower bound value $\underline{\gamma}$ of γ below which $g^* = 0$, and there also exists an upper bound value $\overline{\gamma}$ of γ above which $g^* = 0$. In other words, if $\gamma = \underline{\gamma}$ or $\gamma = \overline{\gamma}$, then $H_R^* = 0$. Solving the quadratic function $\theta\phi\gamma = (1+\eta+\delta\gamma)^2$, we derive the values of $\{\underline{\gamma}, \overline{\gamma}\}$ given by

$$\{\underline{\gamma}, \overline{\gamma}\} = \frac{\theta\phi - 2(1+\eta)\delta \pm \sqrt{[\theta\phi - 4(1+\eta)\delta]\,\theta\phi}}{2\delta^2}. \tag{27}$$

We summarize these results in Proposition 1 and plot g^* as a function of γ in Figure 1.

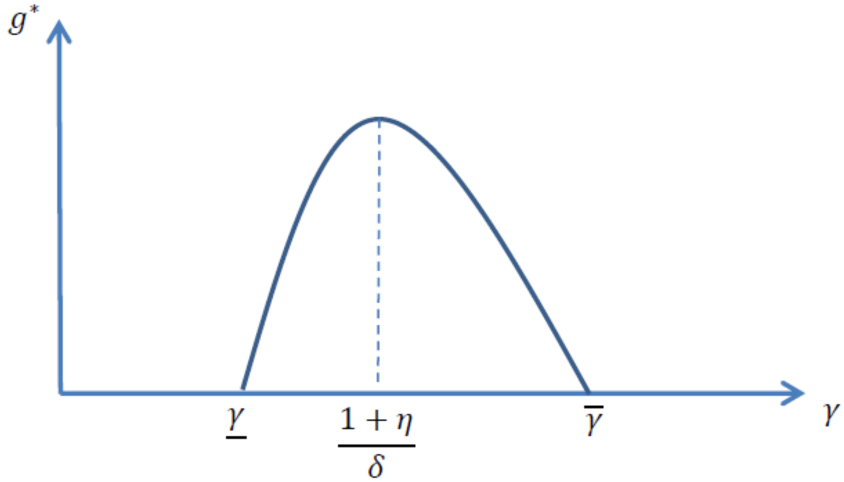

Figure 1: Steady-state effect of education preference on growth

Proposition 1 *An increase in the degree of parental preference for education has an inverted-U effect on the steady-state equilibrium growth rate. Under a sufficiently low or high degree of parental preference for education, the economy is trapped in a zero-growth equilibrium.*

The intuition of the above results can be explained as follows. An increase in the degree of parental preference for education increases education investment and human capital accumulation. However, it also crowds out productive resources for R&D. Specifically, if $\gamma > (1+\eta)/\delta$, then any further increase in γ would lead to a decrease in human-capital-embodied labor supply, which in turn reduces the amount of resources available for innovation. In this case, a stronger degree of parental preference for education is detrimental to economic growth. Furthermore, in the R&D-based growth model, the market size needs to be sufficiently large in order for R&D investment to be profitable. Therefore, when the degree of parental preference takes on a sufficiently high or low value, the market size measured by $(1-l-e)H$ becomes so small that there is no incentive for entrepreneurs to invest in R&D. In this case, the economy is trapped in a stagnant equilibrium with zero economic growth.

3.2 Transition dynamics

In this subsection, we derive the transitional dynamics of the economy. Substituting (17) into (9) yields the following expression for the equilibrium wage rate:

$$w_t = (1-\alpha)\left(\frac{\alpha}{\mu}\right)^{\alpha/(1-\alpha)} N_t. \tag{28}$$

Substituting (28) into (16) yields the following expression for the value of an invention:

$$v_t = \frac{1-\alpha}{\theta}\left(\frac{\alpha}{\mu}\right)^{\alpha/(1-\alpha)}, \tag{29}$$

which is stationary both on and off the balanced growth path. Substituting (28) and (29) into (21) yields

$$w_t(1-l_t-e_t)H_t = N_{t+1}v_t \Leftrightarrow N_{t+1} = \theta N_t(1-l_t-e_t)H_t. \tag{30}$$

Substituting (4) and (5) into (30) yields the growth rate of technology given by

$$g_t \equiv \frac{N_{t+1}}{N_t} - 1 = \frac{\theta}{\phi(1+\eta+\gamma)}\left[\phi H_t + (1-\delta)(H_t)^2\right] - 1, \tag{31}$$

which is decreasing in γ for a given H_t due to the crowding-out effect of education investment but is increasing in H_t due to the positive effect of human capital on innovation. Equation (31) shows that the dynamics of g_t is completely determined by the dynamics of H_t given by (6).

We next determine the transitional path of output. Substituting (15) and (19) into (30) yields

$$\frac{N_{t+1}}{N_t} = \theta(1-l_t-e_t)H_t \Leftrightarrow 1 + \theta H_{R,t} = \theta(H_{Y,t} + H_{R,t}), \tag{32}$$

which shows that $H_{Y,t} = 1/\theta$ even when the economy is off the balanced growth path. As a result, the level of output in (17) simplifies to

$$Y_t = \frac{1}{\theta}\left(\frac{\alpha}{\mu}\right)^{\alpha/(1-\alpha)} N_t, \tag{33}$$

which shows that $Y_{t+1}/Y_t = N_{t+1}/N_t$ at any point in time.

We are now ready to examine the transitional effects of a change in parental preference for education when the degree of education preference γ changes from an initial value γ_0 to a new value γ_1. Suppose at time $t=0$ the economy is at an initial steady state with $\gamma = \gamma_0$. In this case, the initial value of human capital is $H_0 = \phi\gamma_0/(1+\eta+\delta\gamma_0)$, and the initial steady-state equilibrium growth rate is $g_0|_{\gamma=\gamma_0} = \theta\phi\gamma_0/(1+\eta+\delta\gamma_0)^2 - 1$. From (31), we see that when γ increases at time 0 from γ_0 to $\gamma_1 > \gamma_0$, the growth rate at time 0 immediately falls to

$$g_0|_{\gamma=\gamma_1} = \frac{\theta}{\phi(1+\eta+\gamma_1)}\left[\phi H_0 + (1-\delta)(H_0)^2\right] - 1 = \underbrace{\frac{1+\eta+\gamma_0}{1+\eta+\gamma_1}}_{<1}\frac{\theta\phi\gamma_0}{(1+\eta+\delta\gamma_0)^2} - 1 \tag{34}$$

given that H_0 is predetermined. Therefore, a stronger education preference has an initial negative impact on growth. Then, at time $t=1$, the level of human capital increases to

$$H_1 = \frac{\gamma_1}{1+\eta+\gamma_1}[\phi + (1-\delta)H_0] = \underbrace{\frac{1+\eta+\gamma_0}{\gamma_0}\frac{\gamma_1}{1+\eta+\gamma_1}}_{>1}\frac{\phi\gamma_0}{1+\eta+\delta\gamma_0} > H_0, \tag{35}$$

which determines the equilibrium growth rate at time $t=1$ given by

$$g_1 = \frac{\theta}{\phi(1+\eta+\gamma_1)}\left[\phi H_1 + (1-\delta)(H_1)^2\right] - 1 > g_0|_{\gamma=\gamma_1}, \tag{36}$$

where H_1 is given by (35). After the initial decrease, the equilibrium growth rate gradually increases until it reaches the new steady state given by $g^* = \theta\phi\gamma_1/(1+\eta+\delta\gamma_1)^2 - 1$, which may be higher or lower than the initial steady-state growth rate given that g^* is an inverted-U function in γ as demonstrated in (26) and Proposition 1. We summarize these results in Proposition 2 and plot in Figure 2 the transitional paths of g_t when γ increases at time 0 from γ_0 to γ_1.

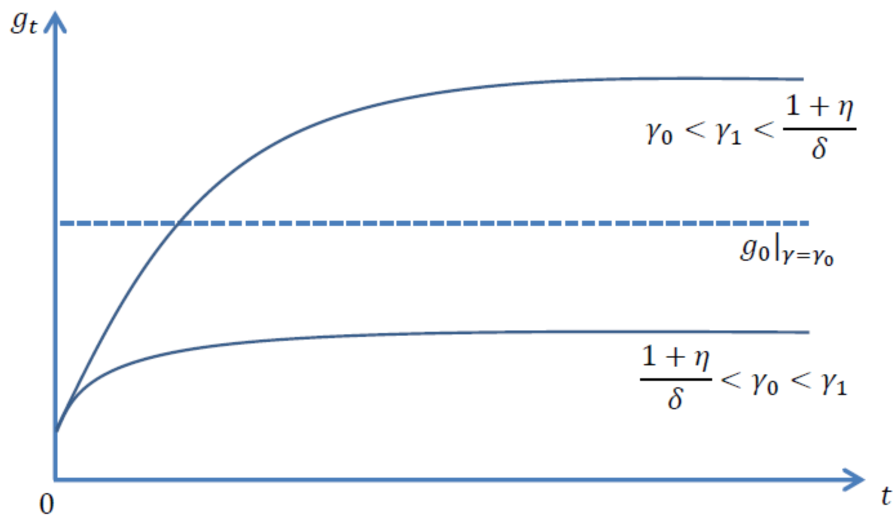

Figure 2: Transitional effect of education preference on growth

Proposition 2 *An increase in the degree of parental preference for education has an initial negative effect on the equilibrium growth rate and a gradual positive effect on the level of human capital. As the level of human capital increases, the equilibrium growth rate also increases. The new steady-state equilibrium growth rate may be higher or lower than the initial steady-state equilibrium growth rate.*

Using (31) and the transitional path of human capital in (6), we can also derive a closed-form solution for the complete transitional paths of human capital and the equilibrium growth rate from any initial state H_t at time t when γ changes from γ_0 to γ_1. From (6), the equilibrium level of human capital at time $t+s$ for any $s \geq 1$ is given by

$$H_{t+s} = \frac{\phi\gamma_1}{1+\eta+\delta\gamma_1}\left\{1-\left[\frac{(1-\delta)\gamma_1}{1+\eta+\gamma_1}\right]^s\right\} + \left[\frac{(1-\delta)\gamma_1}{1+\eta+\gamma_1}\right]^s H_t. \tag{37}$$

If the economy were at an initial steady state at time t, then $H_t = \phi\gamma_0/(1+\eta+\delta\gamma_0)$.

As for the equilibrium growth rate at time $t+s$ for any $s \geq 1$, it is given by

$$g_{t+s} = \frac{\theta}{\phi(1+\eta+\gamma_1)}\left[\phi H_{t+s} + (1-\delta)(H_{t+s})^2\right] - 1, \tag{38}$$

where H_{t+s} is given in (37). Equation (38) shows that for any given initial state H_t, an increase in γ at time t causes an immediate negative effect on the equilibrium growth rate g_t at time

t. Therefore, suppose two economies have the same initial level of human capital H_t at time t. The economy with a stronger cultural preference for education would have a lower initial growth rate but possibly a higher steady-state equilibrium growth rate in the long run.

4 Extensions of the model

In this section, we explore the robustness of our results by considering a number of extensions. In Section 4.1, we introduce public investment in education. In Section 4.2, we introduce a pecuniary transfer from parents to children. In summary, we find that in both cases, parental preference for education continues to exert an inverted-U effect on the steady-state equilibrium growth rate.

4.1 Public education investment

In the benchmark model, we assume that parental involvement is the only input into education. In this subsection, we extend the model to allow for public investment in education. For example, the government needs to recruit teachers to educate children. In this case, we modify the human-capital-accumulation equation in (2) as follows:

$$H_{t+1} = \phi S_t^{\sigma} e_t + (1-\delta) H_t, \tag{39}$$

where S_t denotes public investment in education and is denominated in units of human capital. Specifically, we assume that $S_t = sH_t$, where $s \in (0,1)$ is an education policy parameter. The parameter $\sigma \in (0,1)$ determines the importance of public education in the human-capital-accumulation process. To finance public education, the government levies a tax on the labor income of individuals such that the budget constraint in (3) becomes

$$C_{t+1} = (1 + r_{t+1})(1 - \tau_t) w_t (1 - l_t - e_t) H_t, \tag{40}$$

where $\tau_t \in (0,1)$ is the tax rate on labor income at time t.[12] The government's balanced budget condition is

$$\tau_t w_t (1 - l_t - e_t) H_t = w_t S_t \Leftrightarrow \tau_t = \frac{s}{1 - l_t - e_t}. \tag{41}$$

Because of the income tax, the saving-asset equation becomes

$$(1 - \tau_t) w_t (1 - l_t - e_t) H_t = N_{t+1} v_t \Leftrightarrow w_t (1 - l_t - e_t - s) H_t = N_{t+1} v_t. \tag{42}$$

The rest of the model is the same as before.

Solving the individual's optimization problem, we find that the equilibrium levels of leisure and education in (4) and (5) become

$$l_t = \eta \frac{\phi S_t^{\sigma} + (1-\delta) H_t}{\phi S_t^{\sigma} (1 + \eta + \gamma)}, \tag{43}$$

[12] Alternatively, one can consider a tax on interest income.

$$e_t = \frac{\phi S_t^\sigma \gamma - (1+\eta)(1-\delta)H_t}{\phi S_t^\sigma (1+\eta+\gamma)}, \tag{44}$$

where $S_t = sH_t$. However, the steady-state levels of leisure and education are the same as in the benchmark model. This is because the steady-state level of human capital is now given by

$$H^* = \left(\frac{\phi\gamma}{1+\eta+\delta\gamma}\right)^{1/(1-\sigma)} s^{\sigma/(1-\sigma)}, \tag{45}$$

which is increasing in the education preference parameter γ and the education policy parameter s. Finally, the steady-state level of human-capital-embodied labor supply (net of public education investment) is

$$(1-l^*-e^*)H^* - sH^* = \left(\frac{1}{1+\eta+\delta\gamma} - s\right)\left(\frac{\phi\gamma}{1+\eta+\delta\gamma}\right)^{1/(1-\sigma)} s^{\sigma/(1-\sigma)}. \tag{46}$$

To derive the steady-state equilibrium allocations $\{H_Y, H_R\}$, we also need the following conditions. First, the resource constraint in (19) becomes

$$(1-l_t-e_t)H_t = S_t + H_{Y,t} + H_{R,t} \Rightarrow (1-l^*-e^*)H^* - sH^* = H_Y + H_R. \tag{47}$$

Second, the R&D zero-profit condition is the same as before such that

$$\theta N_t v_t = w_t \Rightarrow H_Y = \frac{\mu}{\mu-1}\left(\frac{1-\alpha}{\alpha}\right)\frac{r}{\theta}. \tag{48}$$

Third, the saving-asset equation also turns out to be the same as before such that

$$w_t(1-l_t-e_t-s)H_t = N_{t+1}v_t \Rightarrow \frac{(1-\alpha)(H_Y+H_R)}{H_Y} = \frac{\alpha(1+\theta H_R)}{r}\left(\frac{\mu-1}{\mu}\right). \tag{49}$$

Solving (46)-(49) yields $H_Y^* = 1/\theta$ and

$$H_R^* = \left(\frac{1}{1+\eta+\delta\gamma} - s\right)\left(\frac{\phi\gamma}{1+\eta+\delta\gamma}\right)^{1/(1-\sigma)} s^{\sigma/(1-\sigma)} - \frac{1}{\theta}. \tag{50}$$

From (50), we have the steady-state equilibrium growth rate of technology given by

$$g^* \equiv \frac{\Delta N_t}{N_t} = \theta H_R^* = \theta\left(\frac{1}{1+\eta+\delta\gamma} - s\right)\left(\frac{\phi\gamma}{1+\eta+\delta\gamma}\right)^{1/(1-\sigma)} s^{\sigma/(1-\sigma)} - 1, \tag{51}$$

which is an inverted-U function in the education preference parameter γ and the education policy parameter s. Proposition 3 summarizes these results. As shown in (45), an increase in either γ or s leads to a larger stock of human capital, which has a positive effect on innovation. However, the increase in γ or s also crowds out the amount of human capital available for R&D, which causes a negative effect on innovation. Combining these two effects gives rise to an overall inverted-U effect on the steady-state equilibrium growth rate. Furthermore, the growth-maximizing value of s is given by $s = \sigma/(1+\eta+\delta\gamma)$, which is decreasing in γ; therefore, in a society that has a strong preference for education, the government may have limited room to stimulate economic growth through education policy. Similarly, the growth-maximizing value of γ is given by

$$\gamma = \frac{1+\eta}{\delta}\left[\frac{1-s\,(1+\eta)}{1-\sigma+s\,(1+\eta)}\right],$$

which is also decreasing in s.

Proposition 3 *In the presence of public investment in education, an increase in either the degree of education preference γ or the level of public education investment s has an inverted-U effect on the steady-state equilibrium growth rate.*

4.2 Pecuniary transfer

In the benchmark model, we made the assumption that education is the only form of bequest from parents to children. In this subsection, we return to the benchmark model without public education investment (i.e., $s = \sigma = 0$) but extend the model to allow for a pecuniary transfer from parents to children. In particular, we assume that parents are altruistic and derive utility from this pecuniary transfer. The utility function in (1) becomes

$$U^t = u(l_t, C_{t+1}, H_{t+1}) = \eta \ln l_t + \ln C_{t+1} + \gamma \ln H_{t+1} + \beta \ln T_{t+1}, \tag{52}$$

where T_{t+1} denotes an income transfer from an individual to her child, and the parameter $\beta > 0$ measures the degree of this parental altruism. Given this pecuniary transfer, the budget constraint of an individual becomes

$$C_{t+1} + T_{t+1} = (1 + r_{t+1})[w_t(1 - l_t - e_t)H_t + T_t], \tag{53}$$

where T_t is an income transfer that the individual receives from her parent, and T_{t+1} is an income transfer from the individual to her child.

Solving the individual's optimization problem, the optimality condition for income transfer T_{t+1} is given by

$$T_{t+1} = \frac{\beta}{1-\beta}(1 + r_{t+1})[w_t(1 - l_t - e_t)H_t + T_t]. \tag{54}$$

On the balanced growth path, we have the following balanced-growth condition:

$$\frac{T_{t+1}}{T_t} = \frac{Y_{t+1}}{Y_t} = \frac{N_{t+1}}{N_t} = 1 + g^*, \tag{55}$$

where g^* is the steady-state equilibrium growth rate of technology. It can be shown that the steady-state equilibrium levels of leisure, education and human capital are given by

$$l^* = \frac{\eta}{1+\eta+\delta\gamma+\beta(g^*-r^*)/(1+g^*)}, \tag{56}$$

$$e^* = \frac{\delta\gamma}{1+\eta+\delta\gamma+\beta(g^*-r^*)/(1+g^*)}, \tag{57}$$

$$H^* = \frac{\phi\gamma}{1+\eta+\delta\gamma+\beta(g^*-r^*)/(1+g^*)}, \tag{58}$$

where r^* is the steady-state equilibrium interest rate. Combining (56), (57) and (58) yields the human-capital-embodied labor supply given by

$$(1-l^*-e^*)H^* = \frac{\phi\gamma\left[1+\beta(g^*-r^*)/\left(1+g^*\right)\right]}{\left[1+\eta+\delta\gamma+\beta(g^*-r^*)/\left(1+g^*\right)\right]^2}. \tag{59}$$

To derive the steady-state equilibrium allocations $\{r^*, H_Y^*, H_R^*\}$, we also need the following conditions. First, the resource constraint is the same as (19) in the benchmark model. Second, the R&D zero-profit condition becomes the same condition as (20) in the benchmark model. Third, in the presence of a pecuniary transfer, the saving-asset equation is modified to

$$w_t(1-l_t-e_t)H_t + T_t = N_{t+1}v_t \Rightarrow \frac{(1-\alpha)\left(H_R^*+H_Y^*\right)}{H_Y^*} + \frac{T_t}{Y_t} = \frac{\alpha\left(1+\theta H_R^*\right)}{r^*}\left(\frac{\mu-1}{\mu}\right), \tag{60}$$

where the steady-state equilibrium transfer-output ratio is

$$\frac{T_t}{Y_t} = \frac{(1-\alpha)\left(H_R^*+H_Y^*\right)}{H_Y^*}\frac{\beta(1+r^*)}{1+g^*+\beta(g^*-r^*)}.$$

Solving (19)-(20) and (59)-(60) yields the steady-state equilibrium allocations $\{r^*, H_Y^*, H_R^*\}$ given by

$$r^* = \frac{\alpha\left(\mu-1\right)}{\mu\left(1-\alpha\right)+\beta\left(\mu-\alpha\right)}, \tag{61}$$

$$H_Y^* = \frac{1}{\theta}\frac{\mu\left(1-\alpha\right)}{\mu\left(1-\alpha\right)+\beta\left(\mu-\alpha\right)}, \tag{62}$$

$$H_R^* = (1-l^*-e^*)H^* - H_Y^*, \tag{63}$$

where $(1-l^*-e^*)H^*$ is a function of g^* as shown in (59).

Substituting (59) into (63), we can express the implicit function that determines $g^* = \theta H_R^*$ as follows:

$$\frac{g^*}{\theta} = \frac{\phi\gamma\left[1+\beta(g^*-r^*)/\left(1+g^*\right)\right]}{\left[1+\eta+\delta\gamma+\beta(g^*-r^*)/\left(1+g^*\right)\right]^2} - H_Y^*, \tag{64}$$

where r^* and H_Y^* are independent of g^* and γ as shown in (61) and (62). Figure 3 plots (64).[13] As γ increases, the right-hand side (RHS) of (64) initially increases and then decreases eventually. Given that the left-hand side (LHS) of (64) is increasing in g^*, the steady-state equilibrium growth rate g^* is an inverted-U function in education preference γ as in the benchmark model. Proposition 4 summarizes this result and also presents the growth-maximizing value of γ. The proof is relegated to the appendix.

[13] In Figure 3, we plot the case in which the RHS is increasing. However, the RHS can also be decreasing, in which case the comparative static result is the same.

Proposition 4 *In the presence of a pecuniary transfer from parents to children, there exists a unique steady-state equilibrium growth rate g^*. An increase in the degree of education preference γ has an inverted-U effect on this steady-state equilibrium growth rate, which is maximized at*

$$\arg\max_{\gamma} g^* = \frac{1+\beta+\eta}{\delta} \frac{\theta\phi\,(1+\beta)}{\theta\phi\,(1+\beta)+4\delta\Phi} \equiv \gamma^*, \tag{65}$$

where Φ is a composite parameter that is defined as $\Phi \equiv \frac{\beta(\mu-\alpha)(1+\beta)}{\beta(\mu-\alpha)+\mu(1-\alpha)}$.

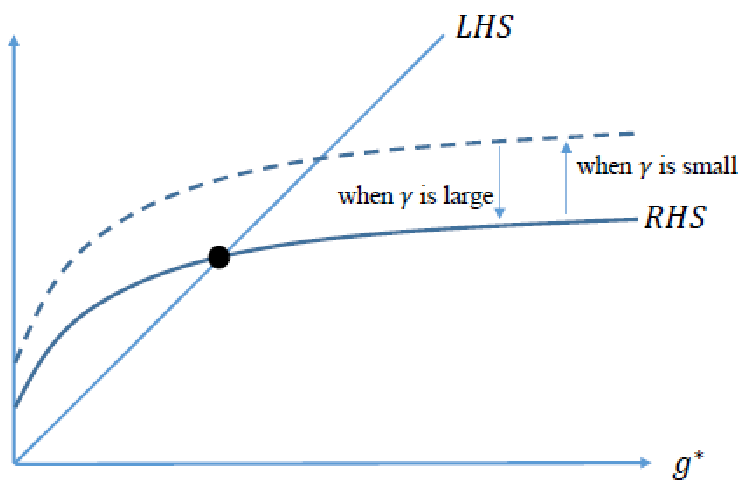

Figure 3: Steady-state equilibrium g^*

5 Conclusion

In this study, we have explored how parental preference for education affects economic growth. A society such as China that has a strong cultural preference for education will accumulate more human capital, which is conducive to innovation; however, the larger investment in education also crowds out resources for other productive activities, such as R&D. As a result, a stronger parental preference for education carries a negative effect on economic growth (in addition to the conventional positive effect), which justifies policymakers' concern discussed in the introduction. Our tractable model allows us to trace out the complete transitional effects of changes in this cultural preference, and we find that the initial growth effect from a strengthening of education preference is always negative.

In an earlier version of this paper,[14] we consider a scale-invariant extension of the model.[15] In this version of the model, the long-run growth rate of technology is solely determined by

[14] See Chu *et al.* (2016).

[15] See Jones (1999) for a discussion of scale effects in the R&D-based growth model.

the growth rate of human capital. Therefore, a stronger education preference inevitably causes only a positive effect on the steady-state equilibrium growth rate. Nevertheless, the negative crowding-out effect still leads to a lower transitional growth rate. In other words, although the negative crowing-out effect may not affect economic growth in the very long run, it always adversely affects the growth rate of an economy before it reaches the steady-state equilibrium.

Compliance with Ethical Standards: The authors declare that they have no conflict of interest.

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Appendix

Proof of Proposition 4. Using $\theta H_Y^* = (1-\beta r^*)/(1+\beta)$ from (61) and (62), we can rewrite (64) as

$$\sqrt{\theta\phi\,(1+\beta)\,(1+g^*)} = \frac{(1+\beta+\eta+\delta\gamma)\,(1+g^*)-\Phi}{\sqrt{\gamma}}, \tag{A1}$$

where $\Phi \equiv \frac{\beta(\mu-\alpha)(1+\beta)}{\beta(\mu-\alpha)+\mu(1-\alpha)}$. The LHS of (A1) is increasing and concave in $1+g^*$ from the origin, whereas the RHS is increasing and linear in $1+g^*$ with a negative y-intercept. Therefore, (A1) uniquely determines $1+g^*$, which in turn determines g^*. To see the effect of γ on g^*, we differentiate the RHS of (A1) with respect to γ and find that it is increasing in γ if and only if

$$(1+g^*)\,\gamma > \underbrace{[(1+\beta+\eta+\delta\gamma)\,(1+g^*)-\Phi]}_{=\sqrt{\theta\phi(1+\beta)(1+g^*)\gamma}\text{ by (A1)}}/(2\delta) \iff (1+g^*)\,\gamma > \theta\phi\,(1+\beta)\,/(4\delta^2). \tag{A2}$$

It is useful to note that (A1) can be reexpressed as

$$\sqrt{\theta\phi\,(1+\beta)\,\tilde{\gamma}} = [(1+\beta+\eta)/\gamma+\delta]\,\tilde{\gamma}-\Phi, \tag{A3}$$

where $\tilde{\gamma} \equiv (1+g^*)\gamma$ is increasing in γ as (A3) implies. Therefore, (A2) shows that the RHS of (A1) is decreasing in γ when γ is small and then becomes increasing in γ when γ is large, which in turn implies that g^* from (A1) is an inverted-U function in γ. The value of γ that maximizes g^* is γ^* given in (65), which can be obtained by substituting $\tilde{\gamma} = \theta\phi\,(1+\beta)\,/(4\delta^2)$ from (A2) into (A3).[16] Finally, it can also be shown that the condition $\theta\phi > 4\delta\,(1+\beta+\eta-\Phi)\,/(1+\beta)$ ensures a positive $g^* > 0$ when g^* is evaluated at $\gamma = \gamma^*$. ■

[16] Derivations are available upon request.